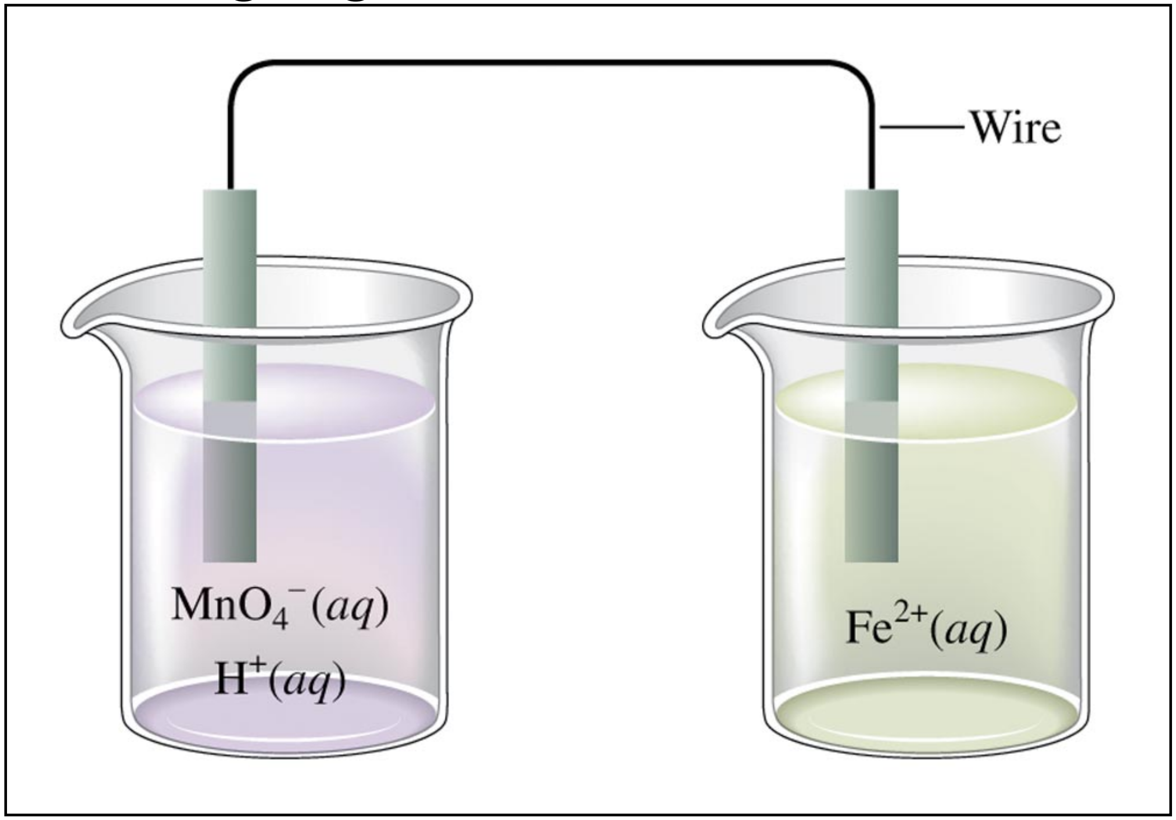
Figure 17.1 A Method to Separate the Oxidizing and Reducing Agents of a Redox Reaction



Careful measurement shows current flows for a second then stops. So flow of electrons will not happen.

Figure 17.2 a-b Galvanic cells can Contain a Salt Bridge as in (a) or a Porous-Disk Connection as in (b)

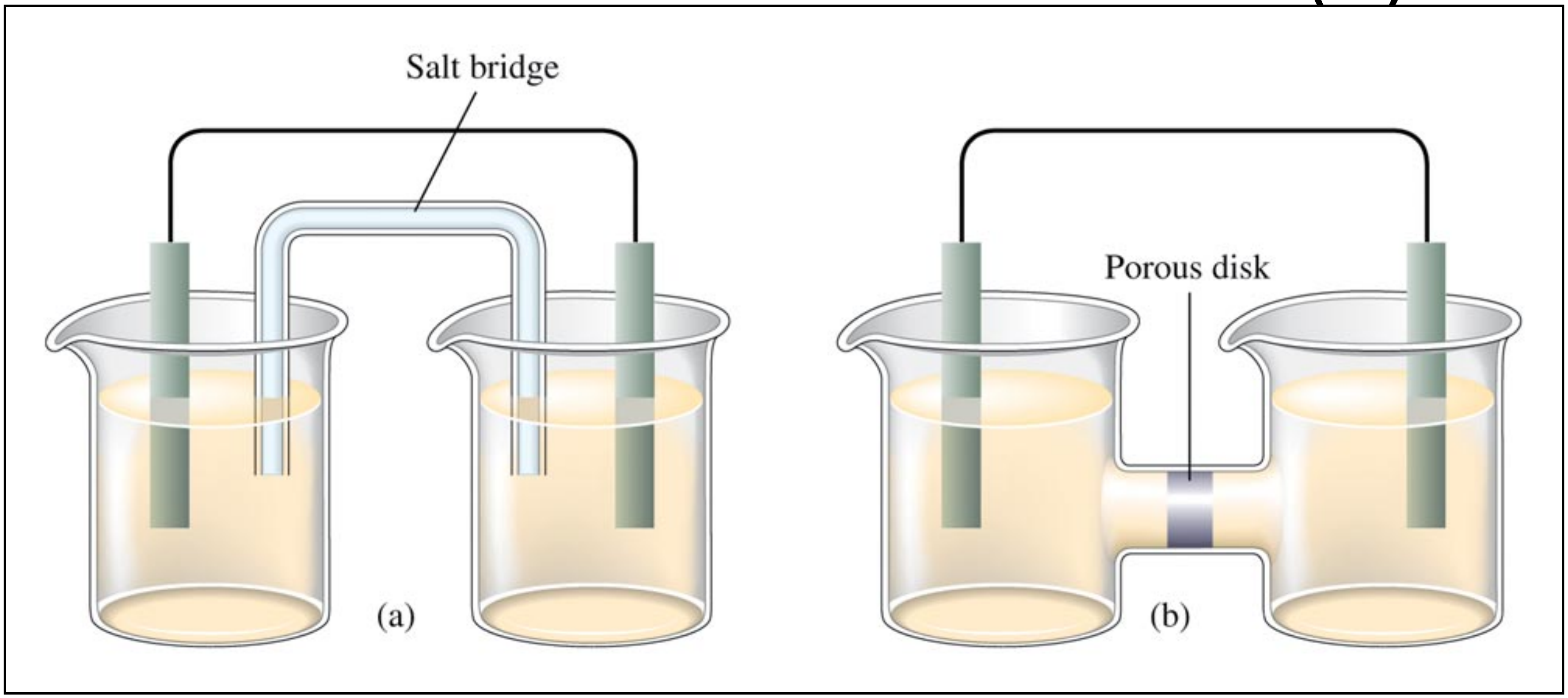


Figure 17.3 a-b The Electrode Compartment in Which Oxidation occurs is called the Anode; the Electrode Compartment in which Reduction Occurs is Called the Cathode

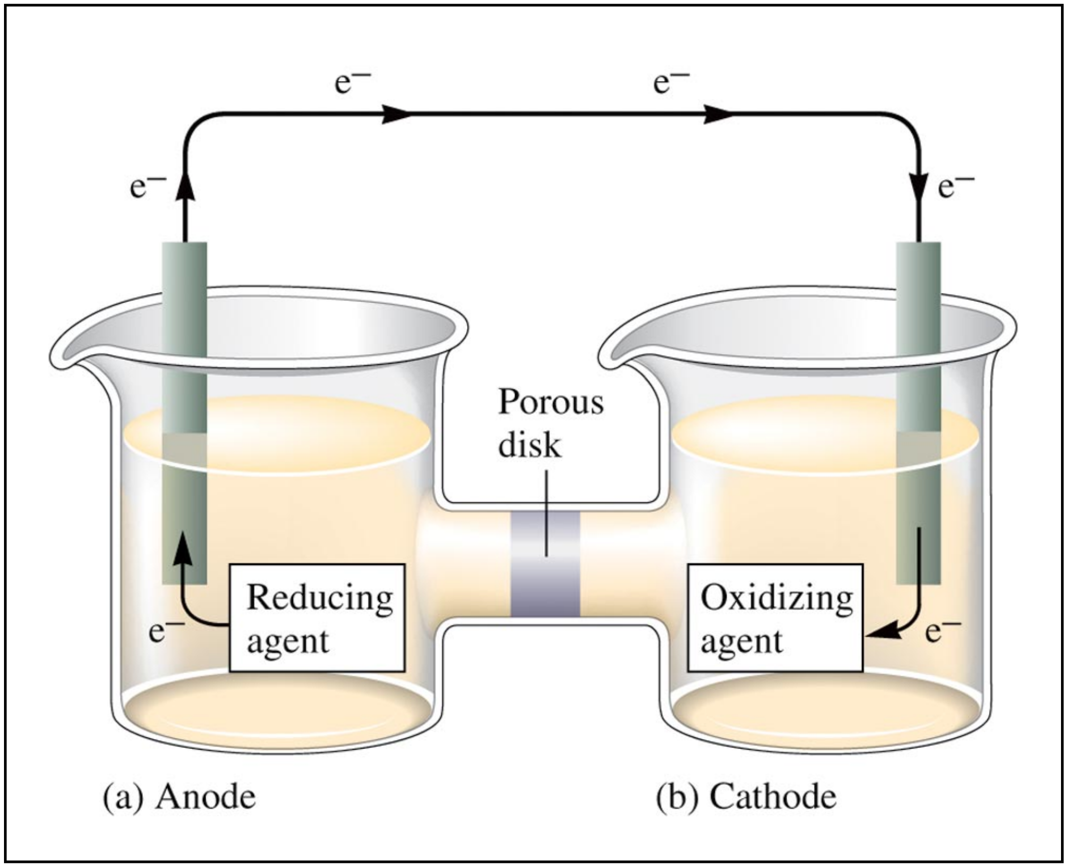


Figure 17.4 Digital Voltmeters Draw only a Negligible Current and are Convenient to Measure Cell Potential

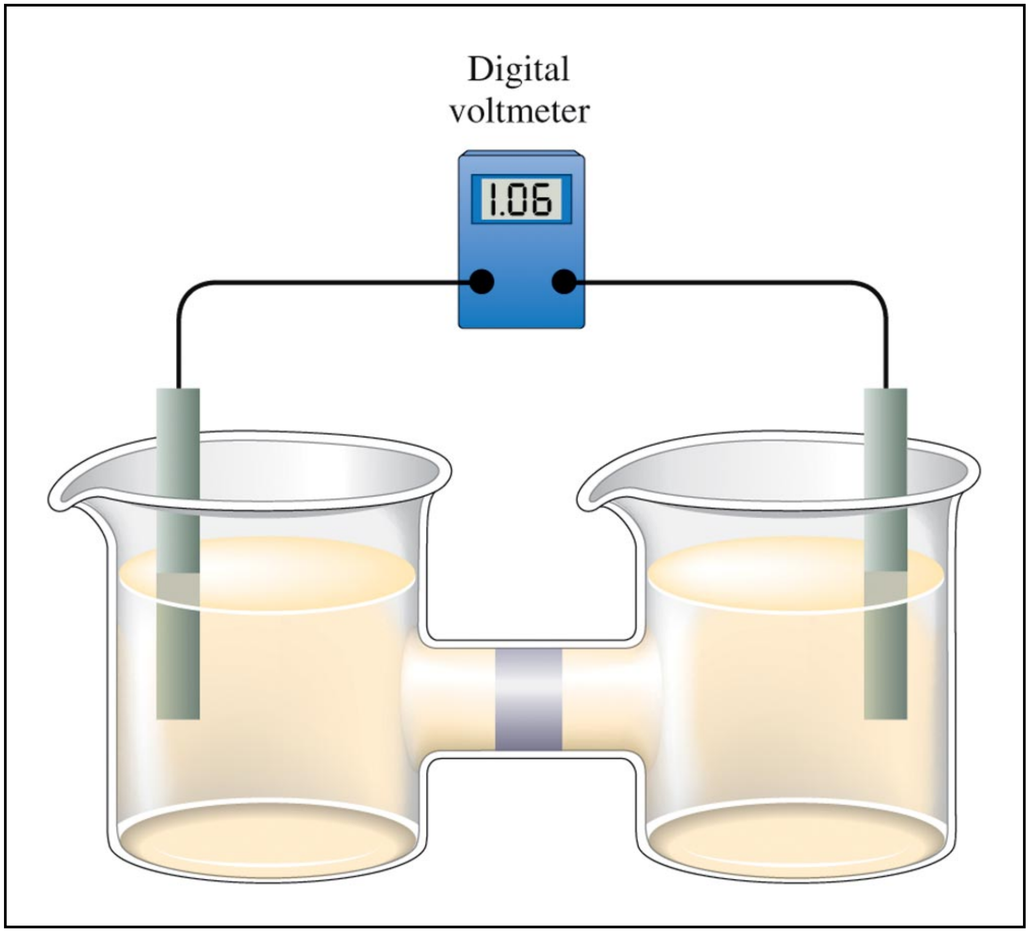


Figure 17.5 a-b Reaction in a Galvanic Cell

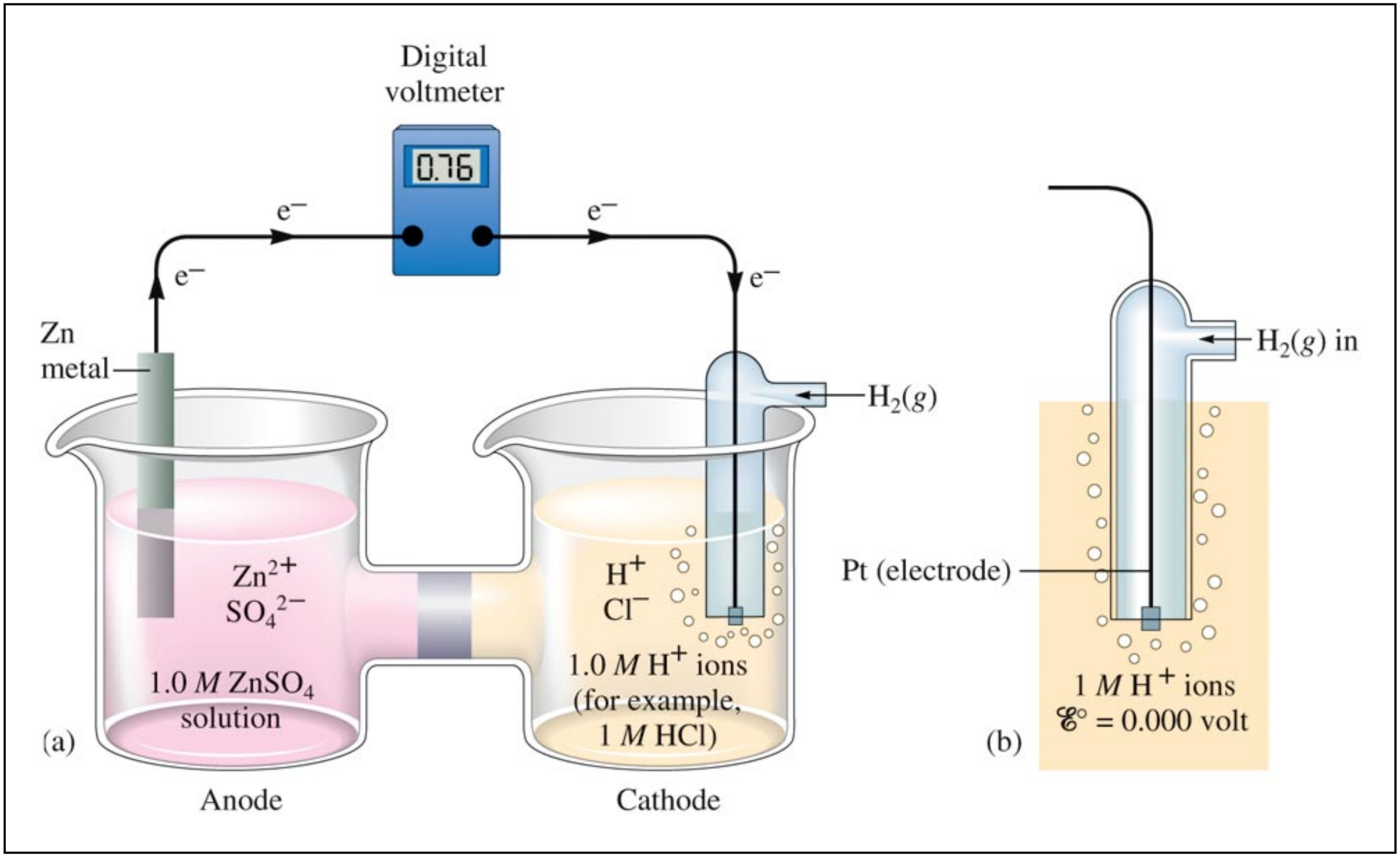


Figure 17.6 A Galvanic Cell involving the Half-Reactions

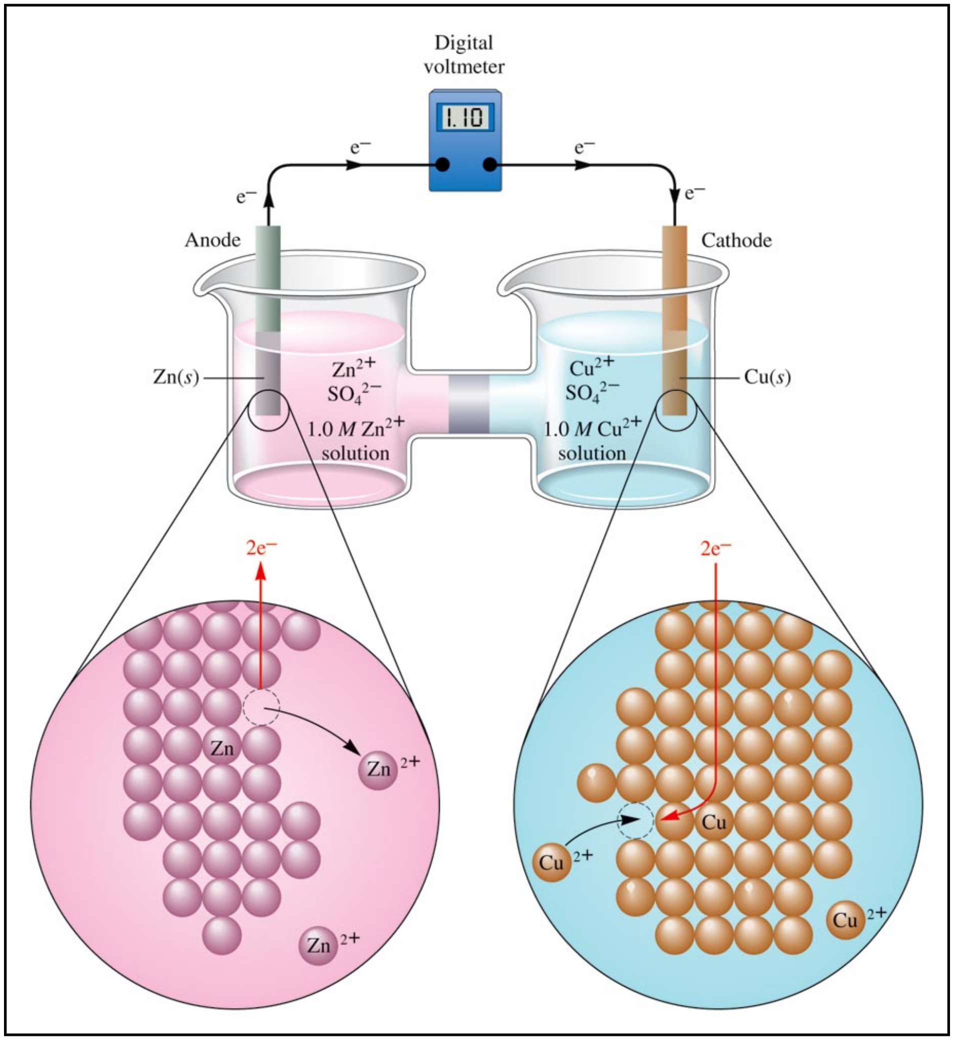


Table 17.1 Standard Reduction Potentials at 25°C (298K) for Many Common Half-Reactions

TABLE 17.1 Standard Reduction Potentials at 25°C (298 K) for Many Common Half-Reactions

Half-Reaction	ℰ° (V)	Half-Reaction	ℰ° (V)
$F_2 + 2e^- \rightarrow 2F^-$	2.87	$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	0.40
$Ag^{2+} + e^- \rightarrow Ag^+$	1.99	$Cu^{2+} + 2e^- \rightarrow Cu$	0.34
$Co^{3-} + e^- \rightarrow Co^{2-}$	1.82	$Hg_2Cl_2 + 2e^- \rightarrow 2Hg + 2Cl^-$	0.27
$H_2O_2 + 2H^- + 2e^- \rightarrow 2H_2O$	1.78	$AgCl + e^- \rightarrow Ag + Cl^-$	0.22
$Ce^{4+} + e^- \rightarrow Ce^{3+}$	1.70	$SO_4^{2-} + 4H^+ + 2e^- \rightarrow H_2SO_3 + H_2O$	0.20
$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$	1.69	$Cu^{2+} + e^- \rightarrow Cu^+$	0.16
$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$	1.68	$2H^+ + 2e^- \rightarrow H_2$	0.00
$2e^- + 2H^+ + IO_4^- \rightarrow IO_3^- + H_2O$	1.60	$Fe^{3+} + 3e^- \rightarrow Fe$	−0.036
$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$	1.51	$Pb^{2+} + 2e^- \rightarrow Pb$	−0.13
$Au^{3+} + 3e^- \rightarrow Au$	1.50	$Sn^{2+} + 2e^- \rightarrow Sn$	−0.14
$PbO_2 + 4H^+ + 2e^- \rightarrow Pb^{2+} + 2H_2O$	1.46	$Ni^{2+} + 2e^- \rightarrow Ni$	−0.23
$Cl_2 + 2e^- \rightarrow 2Cl^-$	1.36	$PbSO_4 + 2e^- \rightarrow Pb + SO_4^{2-}$	−0.35
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$	1.33	$Cd^{2+} + 2e^- \rightarrow Cd$	−0.40
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	1.23	$Fe^{2+} + 2e^- \rightarrow Fe$	−0.44
$MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$	1.21	$Cr^{3+} + e^- \rightarrow Cr^{2+}$	−0.50
$IO_3^- + 6H^+ + 5e^- \rightarrow \frac{1}{2}I_2 + 3H_2O$	1.20	$Cr^{3+} + 3e^- \rightarrow Cr$	−0.73
$Br_2 + 2e^- \rightarrow 2Br^-$	1.09	$Zn^{2+} + 2e^- \rightarrow Zn$	−0.76
$VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$	1.00	$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$	−0.83
$AuCl_4^- + 3e^- \rightarrow Au + 4Cl^-$	0.99	$Mn^{2+} + 2e^- \rightarrow Mn$	−1.18
$NO_3^- + 4H^+ + 3e^- \rightarrow NO + 2H_2O$	0.96	$Al^{3+} + 3e^- \rightarrow Al$	−1.66
$ClO_2 + e^- \rightarrow ClO_2^-$	0.954	$H_2 + 2e^- \rightarrow 2H^-$	−2.23
$2Hg^{2+} + 2e^- \rightarrow Hg_2^{2+}$	0.91	$Mg^{2+} + 2e^- \rightarrow Mg$	−2.37
$Ag^+ + e^- \rightarrow Ag$	0.80	$La^{3+} + 3e^- \rightarrow La$	−2.37
$Hg_2^{2+} + 2e^- \rightarrow 2Hg$	0.80	$Na^+ + e^- \rightarrow Na$	−2.71
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	0.77	$Ca^{2+} + 2e^- \rightarrow Ca$	−2.76
$O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$	0.68	$Ba^{2+} + 2e^- \rightarrow Ba$	−2.90
$MnO_4^- + e^- \rightarrow MnO_4^{2-}$	0.56	$K^+ + e^- \rightarrow K$	−2.92
$I_2 + 2e^- \rightarrow 2I^-$	0.54	$Li^+ + e^- \rightarrow Li$	−3.05
$Cu^+ + e^- \rightarrow Cu$	0.52		

QUESTION

Using Standard Reduction Potential values, determine the voltage for a galvanic cell made from:

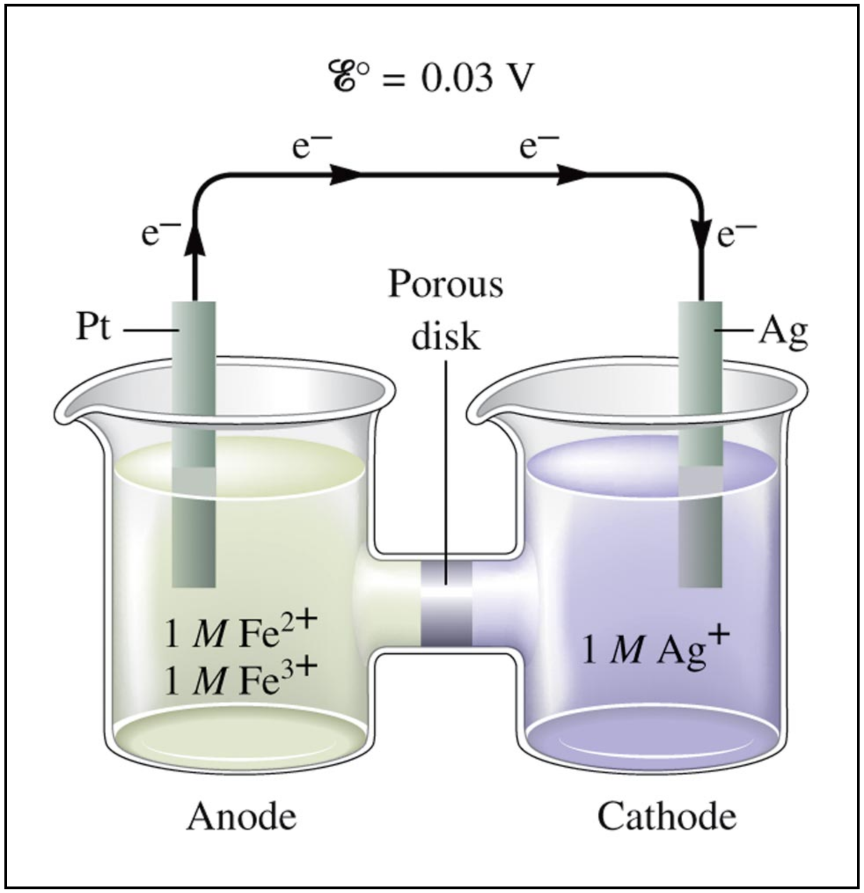
$Ca(s)|Ca^{2+}(aq)||Al^{3+}(aq)|Al(s)$ at 25.0°C.

Answer = 1.10 V

Describe the cell for the following half-reactions:

$Fe^{3+} + e^- \rightarrow Fe^{2+}$ $E^o = 0.77V$

$Ag^+ + e^- \rightarrow Ag$ $E^o = 0.80V$



QUESTION

Using the Standard Reduction Potential table, determine the free energy change for the reaction in a cell made from the following:

$$Zn\ (s) \mid Zn^{2+}\ (aq) \parallel Cr^{3+}\ (aq) \mid Cr\ (s)$$

Answer = –17 kJ using book values
–12kJ using AP values

QUESTION

The following unbalanced redox reaction is taking place at standard conditions in two separate beakers connected by a salt bridge. Which of the following would cause the voltage of the cell to become less?

$$Al\ (s) + MnO_4^-\ (aq) \rightarrow Al^{3+}\ (aq) + Mn^{2+}\ (aq)$$

1. Decreasing the concentration of MnO_4^-.
2. Decreasing the amount of Al.
3. Decreasing the concentration of Mn^{2+}.
4. Without changing the volume, decreasing everything by 0.10 mole.

Describe the cell for the following half-reactions:

$VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O \quad E^o = 1.00V$

$Zn^{2+} + 2e^- \rightarrow Zn \quad E^o = -0.76V$

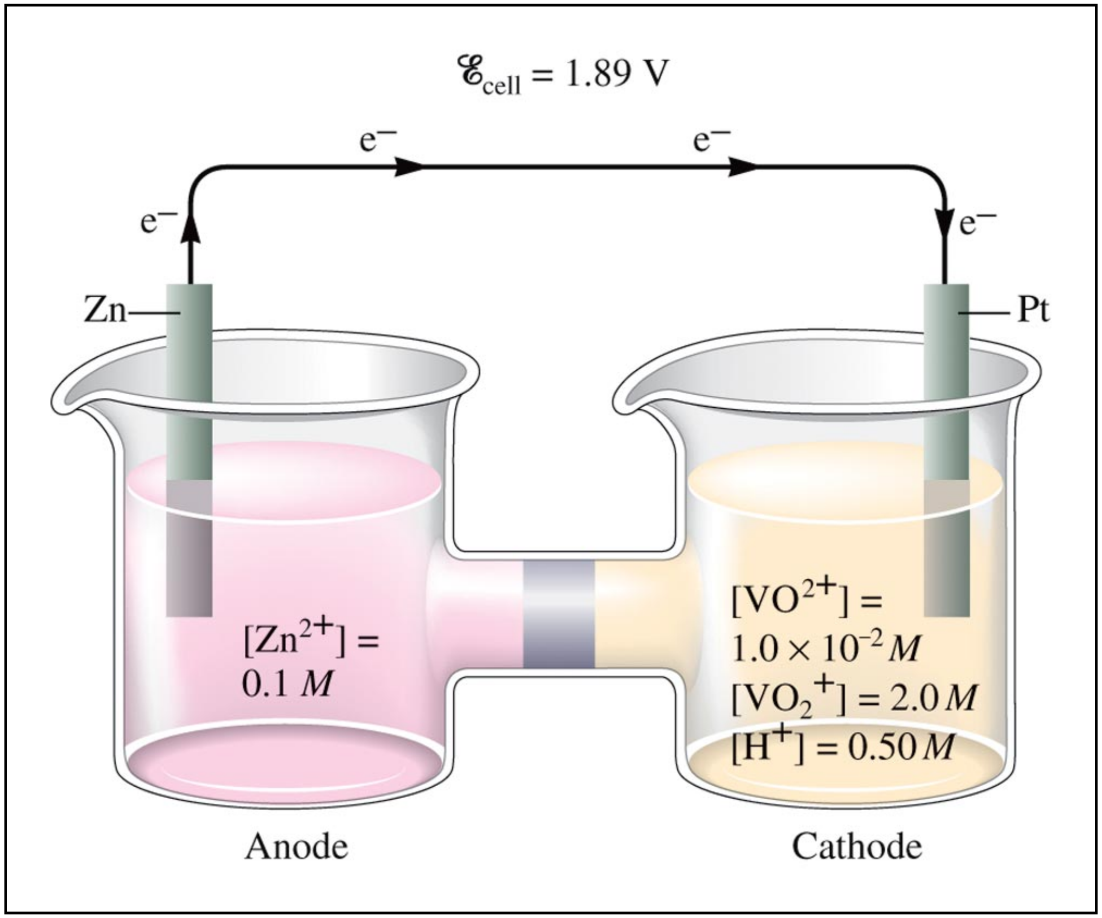
Where: T = 25°C

$[VO_2^+] = 2.0\ M$

$[H^+] = 0.50\ M$

$[VO^{2+}] = 0.010\ M$

$[Zn^{2+}] = 0.10\ M$



QUESTION

Using Standard Reduction Potentials, determine the equilibrium constant at 25°C for the redox reaction that would take place in a galvanic cell made from 1.0 M solutions of Mn^{2+} and Al^{3+} and their appropriate solid metals.

Answer = 5.4×10^{48}

Large *K* is not uncommon for redox reactions

Figure 17.14 A Common Dry Cell Battery

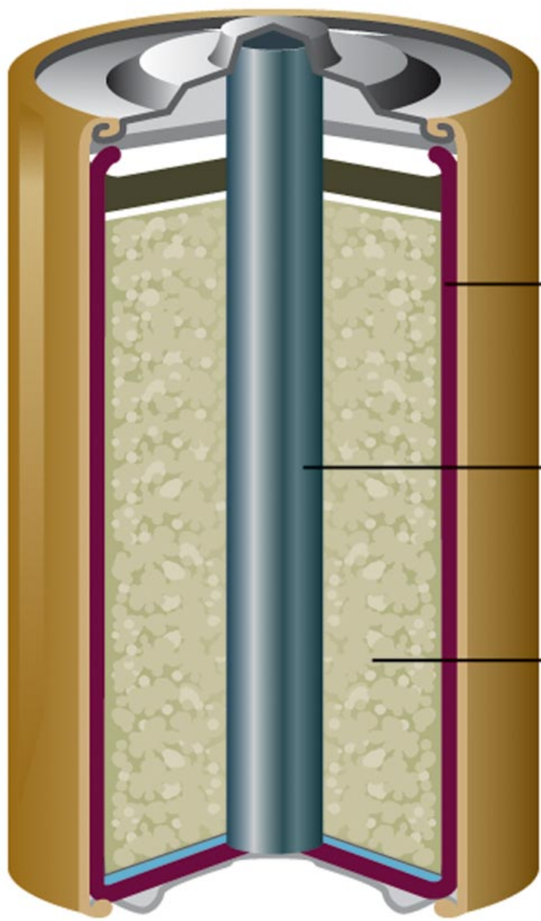
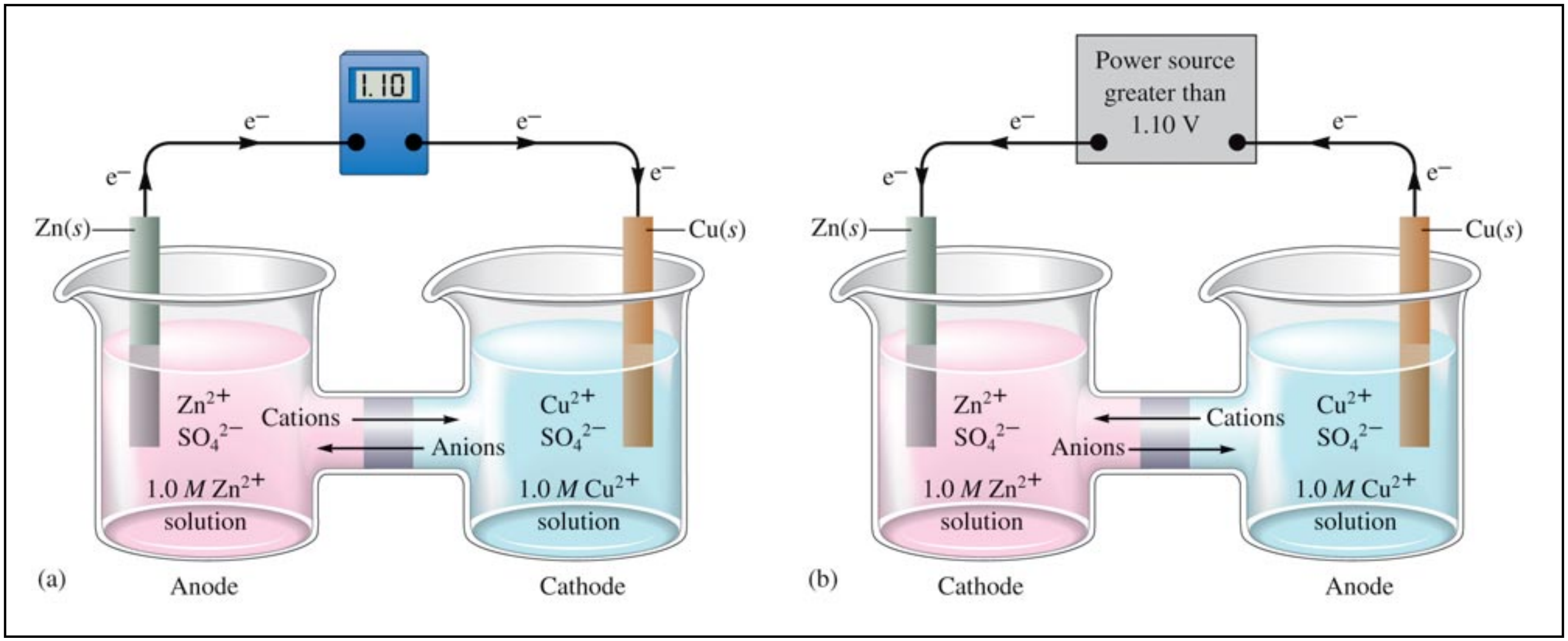
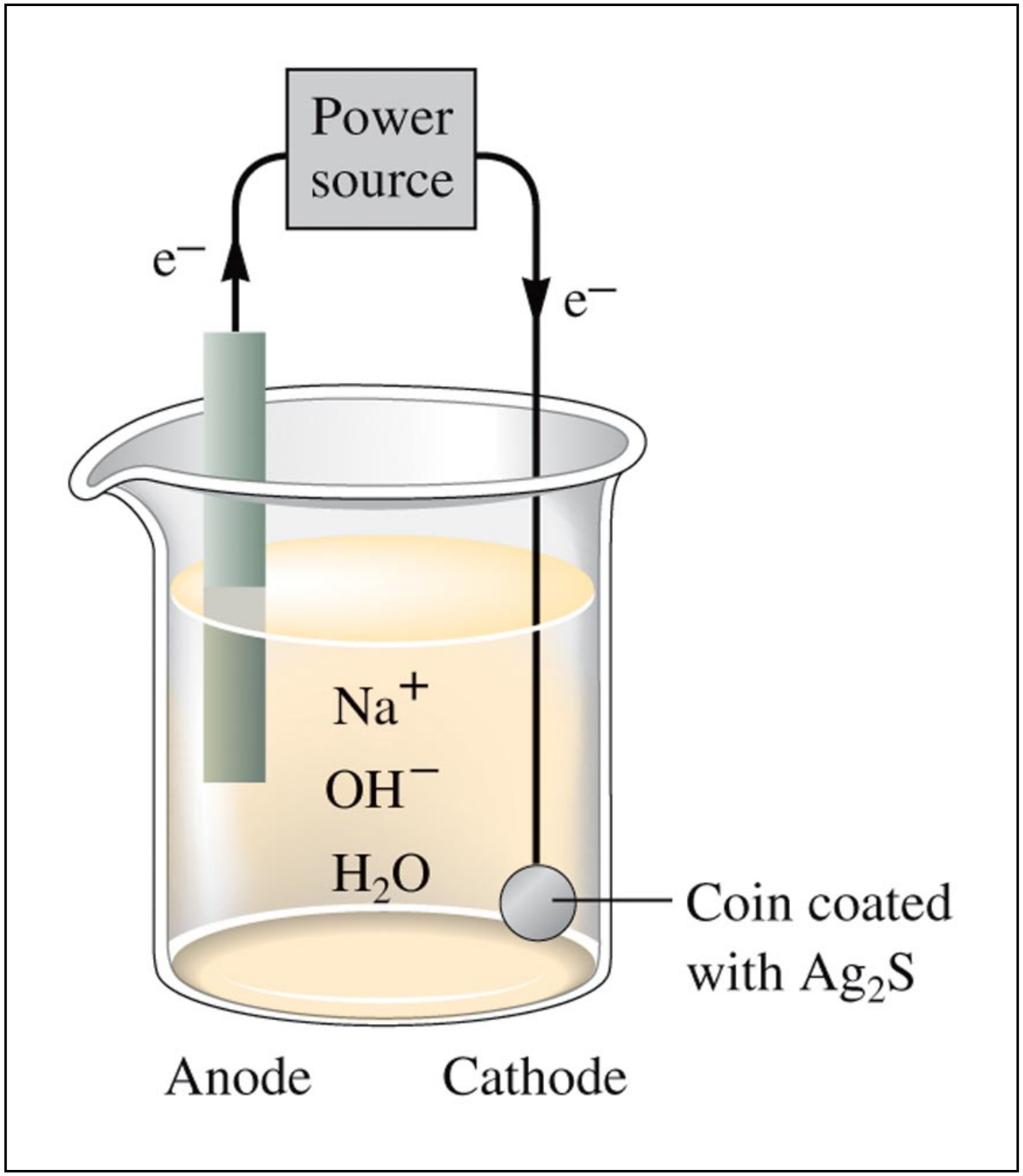


Figure 17.19 a-b (a) A Standard Galvanic Cell Based on the Spontaneous Reaction Zn + Cu^{2+} - Zn^{2+} + Cu (b) A Standard Electrolytic Cell. A Power Source Forces the Opposite Reaction Cu + Zn^{2+} - Cu^{2+} + Zn.



Coin Connected to the Cathode of an Electrolytic Cell in a Dilute Sodium Hydroxide Solution



QUESTION

If you decided to chrome plate your spatula in chemistry lab, how long would it take to plate out 0.850 grams of Cr (from a solution of Cr^{3+}) if you used a current of 10.0 amps?

Answer = 473 seconds

QUESTION

Using 4.00 amps of current for 2.00 minutes resulted in plating 0.229 g of tungsten metal (atomic mass = 183.9) from a solution of tungsten ions. What would the oxidation number of the ion of tungsten have to be in the plating solution?

Answer = +4

Figure 17.20 The Electrolysis of Water Produces Hydrogen Gas at the Cathode (on the Right) and Oxygen Gas at the Anode (on the Left)